EXPERIMENT OF TRANSVERSE FEEDBACK SYSTEM AT HLS*

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Abstract

In this paper, the bunch-by-bunch (BxB) transverse feedback systems at Hefei Light Source (HLS) are introduced, and employ an analog system and a digital system. The construction and commissioning for two feedback systems are exhibited. This paper also presents the instability analysis of beam and the experiment result of two systems.

INTRODUCTION

HLS is a synchrotron light source , injecting in the energy of 200MeV and operating in the 800MeV. The multi-cycle multi-turn injection system is used for current accumulation. The range of horizontal tune of HLS is from 3.54 to 3.56, and the range of vertical tune is from 2.58 to 2.60 for user operation.

The injecting beam current usually cannot exceed 120mA without octupole magnet, and the injecting accumulating beam current is about 250mA with octupole magnet because the beam often occur sudden lose due to CB instabilities in storage ring to limit injection further increase. Therefore the constructing beam feedback system began from 2006 year. The analog feedback system prototype has been built and commissioned at 2007 [1,2], and upgrade the analog TFB prototype during 2008 year. At the same time, the development of digital transverse BxB feedback system began at 2007 and has commissioned since 2008 [3].

UPGRADE ANALOG TFB SYSTEM AND EXPERIMENT RESULTS

A block diagram of updated analog TFB system is shown as Figure 1 [4]. The main improvements about the analog feedback include: the position change of 3-tap filter to the front of hybrid; the x y position signal subtract sum signal of beam to reduce the DC component; phase control function to the 3 * f_{RF} signal to maximize the output amplitude; To reduce the reflection between cable and feedthrough as well as other RF devices; Add independent adjustable gain module for x and y feedback signal etc.

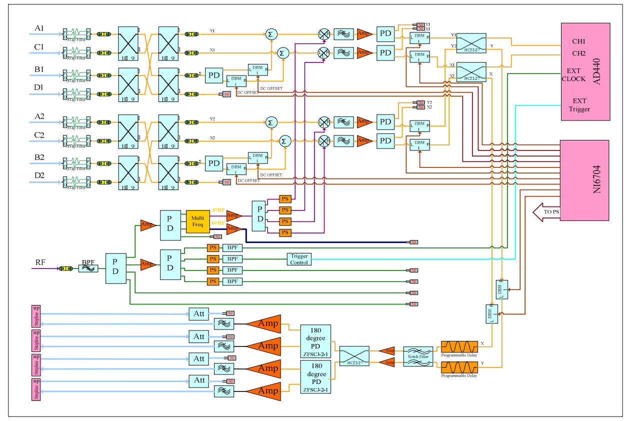

Figure 1: Overview of HLS analog TFB after update.

The important criterion for the feedback effect is damping time and modes tracking. During the commissioning, the damping time and modes tracking have been measured by Turn-by-Turn (TBT) and bunch-by-bunch (BXB) measurement system at beam injecting.

Damping Time Measurement

Figures 2, 3, and 4 show the position of beam and modes tracking measured respectively by TBT and BXB measurement systems at 200MeV injecting when feedback system is off and on.

At 200MeV injection status, the damping time is about 1ms when the feedback system is off. After turning on the feedback system, the damping time is reduced to about 0.1ms and instability Modes are suppressed in effect.

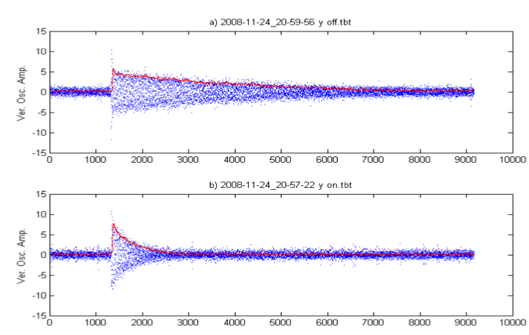

Figure 2: Turn by turn beam tracking of vertical direction at 200MeV injection when feedback system is off and on.

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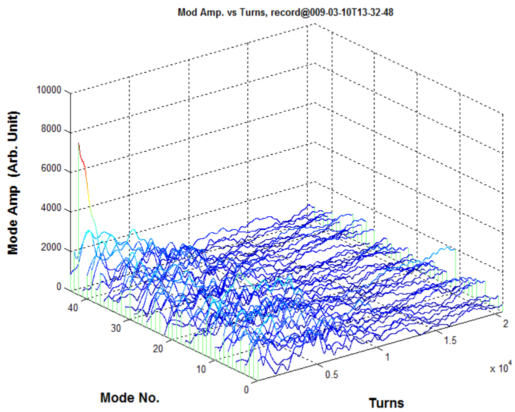

Figure 3: Mode tracking with feedback off.

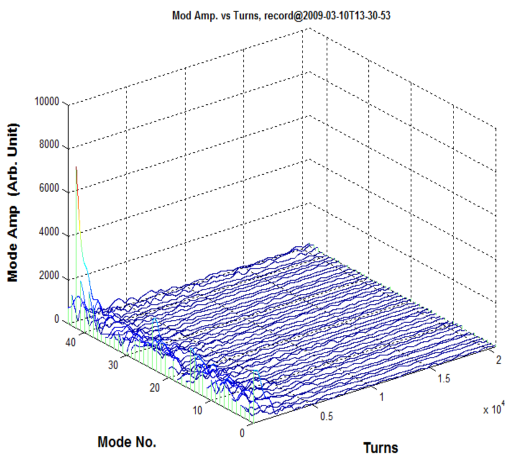

Figure 4: Mode tracking with feedback on.

THE TRANSVERSE DIGITAL FEEDBACK SYSTEM

The scheme of HLS digital TFB is shown in Fig. 5. The system consists of a beam position monitor (BPM), a RF direct sampling front-end, a feedback processor, a clock generator, power amplifiers and a kicker. We employ the SPring-8 FPGA based feedback processor and modified it at NSRL to process horizontal and vertical oscillation signals, independently and simultaneously by one single processor. The processor operates with 1/3 RF frequency LVDS signal, which is produced by a clock generator offered by NSRRC Taiwan. RF direct sampling front-end makes the system simple and easy to adjust.

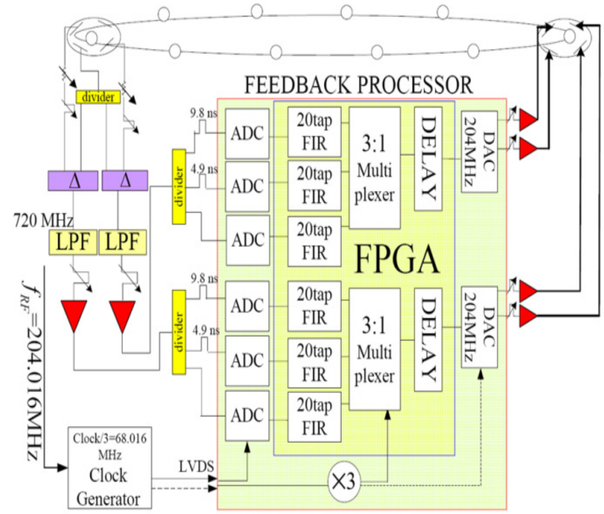

Figure 5: Overview of the HLS digital transverse bunch-by-bunch feedback system.

Commissioning Results

The digital TFB system was commissioned primarily in June 2008 at 800MeV operation with beam current 210mA, horizontal betatron sidebands were observed and suppressed by the feedback system [4].

The digital transverse feedback was commissioned in 200MeV injection in April 2009 [5]. The damping time due to injection bump excitation could be decreased to about 150us by the feedback system. Without feedback and octupole magnet, the damping time was about 20ms as shown in Fig. 6.

The transverse feedback system could improve injection to accumulating more beam current. Without octupole magnet, the beam became unstable (Fig.6 (a)) and the beam current could not exceed 100mA. With octupole magnet on only, the beam current could be stored up to about 250mA. And with feedback on only, the beam current could be accumulated up to 300~320mA. The 358mA peak current is obtained when the feedback and octupole magnet were both turned on. The accumulated beam current curve in adjusting process was shown in Fig. 7.

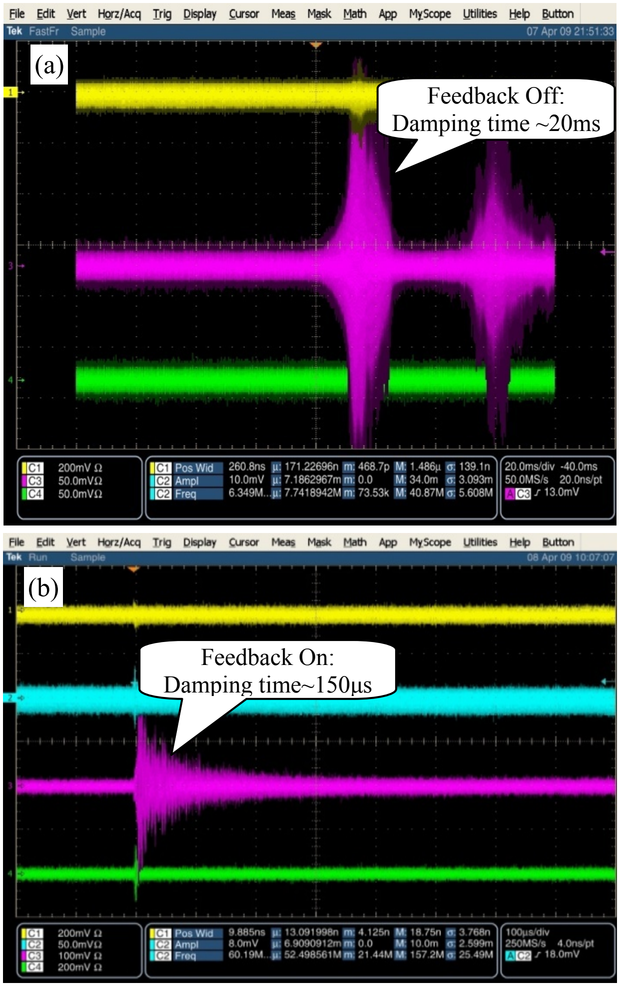

Figure 6: The damping time due to injection bump excitation was decreased by feedback system. (a) damping time was about 20ms due to injection bump excitation; (b) damping time was decreased to about 150µs by feedback system.

SUMMARY

The BxB transverse feedback systems of both the analog and the digital system are constructed and commissioned successfully at HLS. Both analog and digital systems decrease damping time and suppress instability modes and improvement for accumulating current during injection. The digital system is easier for tuning and better for beam current accumulating.

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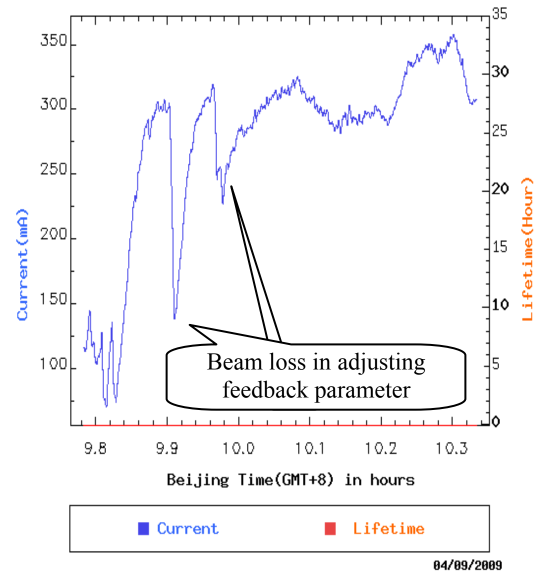

Figure 7: The injecting accumulating beam current curve in commissioning of digital TFB system.

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